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Use of Corn Syrup Solids of Different Dextrose Equivalents in the Manufacture of Frozen Desserts

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USE OF CORN SYRUP SOLIDS OF DIFFERENT DEXTROSE EQUIVALENTS IN THE MANUFACTURE OF FROZEN DESSERTS

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Wiggo F. Axelgard

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INTRODUCTION

Importance of problem

The ice cream industry continually faces the problem of improving its frozen desserts. At the present time corn syrup solids are being used to supplement milk serum solids to improve the body and texture of these products.

One of the problems is to increase the total solids content of frozen desserts without increasing sweetness or developing sandiness in the finished product. There is a limit to the amount of milk serum solids that can be used because of the danger of sandiness and the cost. The use of corn syrup solids helps to overcome these limiting factors.

The corn syrup solids product now used contains a dextrose equivalent of 42. The corn products manufacturers are beginning to make a product with different dextrose equivalents with different degrees of sweetness. Modifications of DE 42 contain dextrose equivalents of 24 and 31 and will add corn syrup solids of different dextrose equivalents or degrees of sweetness to these frozen desserts.

Robert L. Lloyd (11) defines dextrose equivalent as follows:

> The percentage of reducing sugars present on a dry basis - indicates the degree to which conversion has been carried in the hydrolysis of starch.

Dextrose has a DE of 100 and is used as the standard. The lower the dextrose equivalent of a product the less the sweetening power.

Purpose of problem

1. To determine the optimum amounts of corn syrup solids to use in building body and texture in frozen desserts without impairing flavor.

2. To determine the comparative value of different amounts of DE 31, DE 24, and DE 42.

REVIEW OF LITERATURE

Corn syrups were first used in ice cream during the First World War when sucrose sugar was scarce and high in price. Sommer (17) reports the results were generally unsatisfactory, but since then the process and the refining of the product have been markedly improved so that corn syrup is now a recognized ingredient in ice cream. Dextrose has been used for some years, and corn syrup in both dry and liquid forms was coming into fairly general use just prior to the Second World War; and when the use of sucrose was restricted, the ice cream industry was ready to use all available supplies of these products.

Turnbow (18) reports that during the period after World War I, industrial chemists perfected means of converting starch into high-quality syrups. The conversion is accomplished by the use of an acid or an enzyme or both. In acid conversion the starch is heated in an acid solution until the desired degree of hydrolysis has been obtained. The reaction is then stopped by neutralizing with a base.

In addition to dextrose and maltose, other products called pro-sugars are formed. These are polysaccharides which can be broken down to form dextrose. The pro-sugars are sometimes known as dextrins; however, they should not be confused with the dextrins of commerce, which they do not resemble.

The proportion of the polysaccharides present in the corn syrup is important as they have a high molecular weight and, therefore, have less effect upon the freezing point of the mix than do either the

monosaccharide or disaccharide sugars. If the conversion is not carried too far, the syrup solids on a dry matter basis would depress the freezing point of the mix to a lesser extent than would sucrose.

Turnbow (18) also reports that at present there are in general two types of corn syrups, medium and high conversion. The medium conversion type is represented by the regular confections type of corn syrup with a dextrose equivalent (DE) of 42; the high conversion type is represented by the enzyme converted type with a dextrose equivalent of about 65. There are, of course, gradations between these extremes. Differences in the composition of three commercial corn syrups are shown by the following analysis:

Syrup 42°Be	Moisture %	Dextrins %	Higher sugars & maltose %	Dextrose %	Ash %
DE 42	19.7	29.6	32.9	17.6	0.2
DE 55	18.9	21.3	31.5	28.1	0.2
DE 63	18.2	9.9	41.0	30.6	0.3

Harry M. Pancoast (14) lists the differences in the composition of the new corn syrup solids as follows:

Syrup 42°Be	Moisture %	Dextrins %	Higher sugars & maltose %	Dextrose %	Ash %
DE 24	3.0-3.5	63.0	29.0	8.0	0.25
DE 31	22.25	47.0	40.0	13.0	0.24
DE 42	3.0-3.5	37.0	41.0	22.0	0.24

The protein content is almost negligible, amounting to only 0.05 percent. The pH range is from 4.8 to 5.2, and SO_2 content negligible at 0.002 to 0.004 percent.

Sommer (17) indicates that in the hydrolysis of corn starch, the hydrolyzate is filtered, decolorized by carbon filtering, and concentrated by vacuum condensing and produces a clear, almost colorless

syrup. The concentration is customarily specified in terms of specific gravity or density as expressed in degrees Baumé.

Glazier and Mack (8) studied the use of a dried form of the medium conversion type corn syrup solids in the manufacture of ice cream. They report that when 20-26 percent of the sucrose was replaced with corn syrup solids, the freezing point was slightly raised, the mix viscosity was somewhat increased, the rate of melting at room temperature decreased and normal whipping qualities were retained in the mix.

Further work by Knechtges and Sommer (9) indicates that ice cream mix with 25 percent replacement of sucrose sugar with corn syrup solids is optimum and a replacement as high as 33-1/3 percent entirely feasible.

The above study showed the effects of these corn syrup solids on the properties of the mix to be as follows:

> Corn syrup solids lower the freezing point of mixes less than sucrose. If 4 pounds of sucrose are replaced by 5 pounds of corn syrup solids (1 percent higher total solids in mix) the freezing points are practically alike.
>
> Corn syrup solids, while acid in reaction, have such a low buffer capacity that they do not affect the acidity of the mix to any significant degree.
>
> The whipping ability of the mix is not affected by the replacement of sucrose by corn syrup solids.
>
> As judged by melt-down tests, corn syrup solids do not exert a stabilizer sparing action in ice creams with moderate stabilizer content.
>
> While favorable effects in delaying sandiness and shrinkage have been observed for corn syrup solids, these effects are too slight to be of practical significance.

Leighton and Williams (10) report that similar experiments wherein the effective sweetness of corn syrup, corn syrup solids and of enzyme converted corn syrup was measured, the results gave sweetness values of 60 for the corn syrup solids and 75 for the solids of the enzyme-converted corn syrup compared with sucrose as 100.

In a study made by Dahlberg and Penczek (5) three different types of corn sweeteners were compared with sucrose; namely, enzyme-converted corn syrup, a dried regular corn syrup or corn syrup solids and hydrated dextrose or corn sugar.

The relative sweetness of these sugars on a dry matter basis at concentrations used in ice cream was found to be sucrose 100, enzyme-converted corn syrup 67, corn syrup solids 49, and dextrose 89.

Based upon this study (5), to secure comparable sweetness, the weight of the dry corn sweeteners required to replace 1 pound of sucrose is as follows: ". . . enzyme-converted corn syrup, 1.5 pounds; corn syrup solids, 2.0 pounds; and dextrose 1.1 pounds."

The extent to which dextrose and corn syrup may replace sucrose has varied with different investigators. Frandsen, Rovner, and Luithly (7) have shown 30 percent of the sucrose could be replaced bo corn syrup and 50 percent by dextrose. Dahle and Caulfield (6) stated that one-third of the sucrose could be replaced with dextrose, while Martin (12) found that 30 percent of the sucrose could be replaced.

Some further studies by Sampey (15) show that previous to sugar rationing it was assumed that about 25 percent of the total sweetening was about the limit that could come from corn sugars; however, we soon found that greater replacement could be made, in some cases over 45 percent of the sucrose being substituted.

Work done by Professor Dahlberg (5) showed that while none of the corn sugars has the sweetness of sucrose, there was no complaint of lack of sweetness in the finished product when high proportions of corn sugars were used. This seems to be due to a supplemental effect

of one sugar on another. A mixture of 16.7 percent sucrose plus 8.3 percent of dextrose was as sweet as a straight 25.0 percent sucrose solution.

According to Agricultural Information Bulletin No. 48 (1), the per capita consumption of the three major sweeteners--sugar, dextrose, and corn syrup--has increased 4 percent since before World War II. This report is based on a study to determine the main factors governing an industry user's choice of sweetening agent or agents in making a frozen dessert product.

Sweetness is a matter of taste, the report continues; there is no chemical test for sweetness, so ice cream manufacturers must rely on consumer taste for a measure of the power of sweetness. Ice cream manufacturers use sweets pretty much according to their own past marketing experience.

The report concludes that total solids in the average mix consists almost entirely of milk fat, nonfat milk solids (serum solids), and the sweetener. These three ingredients amount to about 38 percent of the total weight of the product. Thus, sweeteners are important not only for their sweetening power, which contributes to the flavor and palatability of the product, but also for their contribution to the solids content.

According to an article in the Ice Cream Review (3), the advantage of using corn sweeteners as one of the ingredients in frozen desserts is the favorable effect of such sweeteners on the physical characteristics of the product. In the case of ice cream, the corn sweeteners were believed to give a smoother product and provide a better "melting down" consistency when used in amounts not considered excessive.

The relative sweetness of sugar and corn sweeteners plays an important role. A manufacturer who uses 100 percent sucrose usually desires a sweeter product, or he desires a sufficiently sweet product with a lower total sweetener content. However, when more body is desired without increasing the sweetness, or a reduction of sweetness without sacrificing body, a combination of sucrose with corn sweeteners is indicated.

The article also indicates that smaller manufacturers using corn syrup solids were almost unanimous in advocating the use of this sweetener in frozen desserts as a means of improving body and texture. This was especially true in ice cream, where use of corn syrup solids was reported to impart a desirable consistency to the product. About one-third of the solids users expressed a preference for this material because it permitted an increase in body with a reduction in sweetness. An amount not in excess of 30 percent of the total sweetener was given as the approximate limit.

Another product of interest to the ice cream industry is the high protein milk solids. This product has a low lactose content in comparison with regular non-fat dried milk solids. The approximate percentage of lactose present in this product is 38 percent (17) in comparison to 50 percent (15) in regular non-fat dried milk solids.

METHOD OF PROCEDURE

The information necessary for the completion of this experiment was obtained by conducting separate experiments on ice cream, ice milk, and sherbets. To facilitate and clarify the methods used, the three products will be discussed separately.

General processing

All batches of mix were prepared in 50-pound lots. The mix was pasteurized at 165° F. for 30 minutes; and at this temperature was homogenized at 2700 pounds gauge reading on the first valve and 700 on the second. The sherbet mix contained no butterfat and, consequently, was not homogenized.

After homogenization the mixes were cooled to 40° F. and aged for 24 hours. The mixes were frozen in a 40-quart direct expansion batch freezer of the Cherry Burrell triple dasher type.

Scoring the samples

Samples were scored in accordance with the ice cream score card as adopted by the American Dairy Science Association at Burlington, Va., 1941 (13).

Values as recommended by the American Dairy Science Association are as follows:

a. Flavor 45 points
b. Body and texture 30 points
c. Melting quality 5 points
d. Color 5 points
e. Bacteria 15 points (give all samples same value)
f. Total score 100 points

Because this study involves only sugar variables, the following flavor criticisms were used. Criticisms on body and texture and melt down were used in accordance with the official score card.

a. Flavor

1. Syrup flavor - (slight - definite - pronounced)
2. Lacks sweetness - (" " ")
3. Too sweet - (" " ")
4. Lacks fine flavor - (" " ")
5. Too high flavor - (" " ")

Consumer preference tests were conducted by selecting various groups of non-interested people to serve as a jury. Samples were compared and rated according to choice.

Critical scoring of the samples was done by two experienced judges from the college staff of the Dairy Industry Department.

Method of procedure for ice cream

In this phase of the experiment different combinations of CSS DE 24, DE 42, DE 31, and sucrose sugar were used as outlined below:

	% Sucrose	% CSS DE 42	% CSS DE 24
Series I			
A	15	0	0
B	15	0	1
C	15	0	2
D	15	0	3
Series II			
A	13	2	0
B	13	2	1
C	13	2	2
D	13	2	3
Series III			
A	11	4	0
B	11	4	1
C	11	4	2
D	11	4	3

Series IV

A Best in series II
B Best in series III
C Repeat IV A using CSS DE 31 to replace both CSS DE 42 and DE 24
D Repeat IV B using CSS DE 31 to replace both CSS DE 42 and DE 24

The composition of the mix for ice cream included:

Butterfat -	12.0 %	
Milk serum solids -	12.0 %	
Dariloid stabilizer -	0.3 %	
E4CS emulsifier	0.1 %	(contains polyoxyethelene derivative)

Sweeteners to be varied according to above outline

The milk products used in the mix were obtained from sweet cream containing 33 percent butterfat, skim milk containing 0.09 percent milk solids no fat, and condensed skim milk containing 32.5 percent milk solids not fat.

Specific formulae for ice cream mixes may be found in the appendix.

Results on series I, II, and III were obtained from five trials processed seven days apart. The ice cream was drawn from the freezer at 100 percent overrun and stored in the hardening room for seven days at 15° F. below 0. The samples were then scored for body and texture, flavor, and melting qualities.

Due to the small amount of CSS DE 31 allotted for this experiment, there were only two trials completed on series IV. These trials were drawn from the freezer at 100 percent overrun and stored for three days in the hardening room at 15° F. below 0 and then scored for body and texture, flavor, and melting qualities.

Method of procedure for ice milk

In the manufacture of ice milk the problem of adding total solids to the mix is intensified because of the high percentage of milk serum solids and low percentage of milk fat included in the composition.

In this phase of the experiment different combinations of CSS DE 24, DE 42, DE 31, and sucrose sugar were used as outlined below:

	% Sucrose	% CSS DE 42	% CSS DE 24
Series I			
A	12	3	0
B	12	3	1
C	12	3	2
D	12	3	3
E	12	3	4
F	12	3	5
G	12	3	6
H	12	3	7
I	12	3	8

Series II

A Best in series I
B Second best in series I
C Repeat II A using CSS DE 31 to replace both CSS DE 42 and DE 24
D Repeat II B using CSS DE 31 to replace both CSS DE 42 and DE 24

The composition of the mix for ice milk included:

Butterfat -	4.0 %
Milk serum solids -	13.0 %
Dariloid stabilizer -	0.4 %
E4CS emulsifier -	0.1 % (contains polyoxyethelene derivative)

Sweeteners to be varied according to outline

The milk products used in the mix were obtained from the same sources as those in the ice cream mix.

Specific formulae for ice milk mixes may be found in the appendix.

Results on series I were obtained from ten trials processed seven days apart. The ice milk was drawn from the freezer at 80 percent overrun and stored in the hardening room for seven days at 15° F. below 0 and then scored for body and texture, flavor, and melting qualities.

In order to gain a layman's opinion of the finished product, all samples in series I were submitted to a jury of 18 non-interested people. To insure the best comparison, the samples were divided into two groups of alternate samples. The best two samples of each group were then submitted to a jury of eight non-interested people and their choices taken.

Series II was completed on two trials, drawn from the freezer at 80 percent overrun and stored for three days in the hardening room at 15° F. below 0 and then scored for body and texture, flavor, and melting qualities.

Formulae using low lactose milk powder in combination with the corn syrup solids were studied to compare the effects of this product on quality. The best mix in series I was used as a representative product of corn syrup solids. Two other mixes were used in the comparison. The corn syrup solids, non-fat dried milk solids (N.F.D.M.S.), and the low lactose milk powder were varied by replacing 5 percent of the CSS with low lactose milk powder in one mix and replacing 3 percent of the N.F.D.M.S. in the other mix. The total solids of the mixes were constant at 38.2 percent.

Series III, Formula A. Mix judged as best in ice milk, series I

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	4.0	0.72		4.72
26.8	Condensed skim milk		8.71		8.71
39.6	Skim milk		3.56		3.56
12.0	Sucrose sugar			12.0	12.00
3.0	DE 42				2.91
6.0	DE 24				5.82
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		4.0	12.99	12.0	38.21

Series III, Formula B. Mix using 5 percent low lactose powder in combination with 4 percent CSS

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	4.0	0.7		4.7
7.2	N.F.D.M.S.		6.9		6.9
59.2	Skim milk		5.4		5.4
0.4	Dariloid				0.4
0.1	E4CS				0.1
12.0	Sucrose sugar			12.0	12.0
4.0	DE 42				3.8
5.0	Low lactose				4.9
100.0		4.0	17.8	12.0	38.2

Series III, Formula C. Mix using 3 percent low lactose powder to replace 3 percent of regular N.F.D.M.S.

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	4.0	0.7		4.7
4.1	N.F.D.M.S.		3.9		3.9
59.3	Skim milk		5.4		5.4
0.4	Dariloid				0.4
0.1	E4CS				0.1
12.0	Sucrose sugar			12.0	12.0
3.0	DE 42				2.9
6.0	DE 24				5.9
3.0	Low lactose		2.9		2.9
100.0		4.0	12.9	12.0	38.2

Low lactose milk powder contains 38 percent lactose.

Procedure included three trials on these mixes which were processed and scored in the same manner as those in series I and II.

The three mixes in series III were submitted to a jury of 44 people and their choices as to best, second best and third best were taken.

Method of procedure for sherbet

In this phase of the experiment CSS DE 24, DE 42, DE 31 and sucrose sugar were used as outlined:

	% Sucrose	% CSS DE 42	% CSS DE 24
Series I			
A	12	9	0
B	12	9	1
C	12	9	2
D	12	9	3
E	12	9	4
F	12	9	5
G	12	9	6
H	12	9	7
I	12	9	8

Series II

A Best in series I
B Second best in series I
C Repeat II A using CSS DE 31 to replace both CSS DE 42 and DE 24
D Repeat II B using CSS DE 31 to replace both CSS DE 42 and DE 24

The composition of the mix for sherbets included:

Skim milk - 70.0 %
Gelatin - 0.4 %
Surebet - 0.3 %
Sweeteners as outlined above
Water to make 100 %
Citric acid (50% solution) added at rate of 10 oz. per 100 lbs. of mix
Fruit added at the freezer at the rate of 6 lbs. per 100 lbs. of mix.
Color to taste

Specific formulae for sherbet mixes may be found in the appendix.

Results were obtained from five trials processed seven days apart. The sherbet was drawn from the freezer at 80 percent overrun and stored in the hardening room for seven days at 15° F. below 0 and then judged for body and texture and flavor.

Consumer preference tests were conducted on mixes in series I by submitting the nine samples to a group of non-interested people and having them rate these samples according to their choice.

Due to the limited amount of CSS DE 31 available for this experiment, series II was completed on only one trial. The sherbet was processed in the same manner as series I.

Comparative sales of ice milk and ice cream

To determine the consumer acceptance of the ice milk in comparison with ice cream, a study was made on counter sales at the Utah State Agricultural College creamery. Six duplicate flavors in each product were offered for sale by the cone. The price of the ice milk was less than the price of the ice cream.

Comparative costs

In this experiment five principal products other than butterfat were used to build the total solids content of the frozen desserts. The comparative cost of these products is as follows:

CSS DE 42 -	$ 0.09 per lb.
CSS DE 24 -	0.094 " "
Sucrose sugar -	0.09 " "
Condensed skim milk per lb. of solids -	0.14 " "
N.F.D.M.S. -	0.17 " "

PRESENTATION AND ANALYSIS OF DATA

Ice cream analysis and data

Series I. Series I included four formulae using sucrose and CSS DE 24 as sweeteners. The total solids varied from 39.4 to 42.31 percent.

The tables that follow show the effects of the variable CSS DE 24 content on the scores of the ice cream made from the above formulae. Scores are averaged for five trials.

Table 1. Body and texture scores on ice cream using 15 percent sucrose and varying the CSS DE 24 from 0 to 3 percent

Formula	% Sucrose	% CSS DE 24	Average score
I A	15	0	28.4
I B	15	1	28.9
I C	15	2	29.4
I D	15	3	29.1

From the results indicated in table 1, there appears to be a definite improvement in body and texture scores with the addition of CSS DE 24, with 2 percent DE 24 giving best results.

Table 2. Flavor scores on ice cream using 15 percent sucrose and varying the CSS DE 24 from 0 to 3 percent

Formula	% Sucrose	% CSS DE 24	Average score
I A	15	0	39.6
I B	15	1	39.9
I C	15	2	39.6
I D	15	3	39.0

Results shown in table 2 show very little difference in flavor scores up to 2 percent CSS DE 24. It will be noted that 3 percent gave a marked drop in average score due to the criticism of syrup flavor.

Series II. Series II included four formulae using sucrose CSS DE 42 and CSS DE 24 as sweeteners. The total solids varied from 39.34 to 42.25 percent.

Table 3. Body and texture scores on ice cream using 13 percent sucrose, 2 percent CSS DE 42, and varying the CSS DE 24 from 0 to 3 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
II A	13	2	0	28.9
II B	13	2	1	29.4
II C	13	2	2	29.1
II D	13	2	3	29.2

From the results shown in table 3, there seems to be an improvement in average score of the body and texture when CSS DE 24 is used in combination with 13 percent sucrose and 2 percent CSS DE 42. This difference, however, is not very marked.

Table 4. Flavor scores on ice cream using 13 percent sucrose, 2 percent CSS DE 42 and varying the CSS DE 24 from 0 to 3 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
II A	13	2	0	39.7
II B	13	2	1	39.8
II C	13	2	2	39.2
II D	13	2	3	39.0

Table 4 indicates where 2 percent CSS DE 42 is used with 13 percent sucrose that any increase over 2 percent of CSS DE 24 gives a slight syrup flavor.

Series III. Series III included four formulae using sucrose CSS DE 42 and CSS DE 24 as sweeteners. The total solids varied from 32.28 to 42.19 percent.

Table 5. Body and texture scores on ice cream using 11 percent sucrose, 4 percent CSS DE 42 and varying the CSS DE 24 from 0 to 3 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
III A	11	4	0	29.2
III B	11	4	1	28.9
III C	11	4	2	29.1
III D	11	4	3	29.1

As indicated in table 5 where 4 percent CSS DE 42 is used with 11 percent sucrose, we find practically no improvement in body and texture with the addition of CSS DE 24 up to 3 percent.

Table 6. Flavor scores on ice cream using 11 percent sucrose, 4 percent CSS DE 42 and varying the CSS DE 24 from 0 to 3 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
III A	11	4	0	39.9
III B	11	4	1	39.8
III C	11	4	2	39.0
III D	11	4	3	39.0

Table 6 indicates with 4 percent CSS DE 42, syrup flavor was noticed when 2 or 3 percent CSS DE 24 was added.

Series IV. Rather than use two different corn syrup solids, it was felt that one with a dextrose equivalent of 31 could replace both DE 42 and DE 24 with the same results.

In series IV a comparison was made using formulae II B and III A and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24.

There were only two trials completed on series IV which was not enough to draw a definite conclusion; however, the comparison showed little difference in body and texture and no difference in flavor.

The addition of corn syrup solids of varying amounts in this experiment showed no significant differences in melt down characteristics.

Ice milk analysis and data

Series I. Series I included nine formulae with the following sweeteners: 12 percent sucrose, 3 percent CSS DE 42 and the CSS DE 24 varied from 0 to 8 percent. The total solids of these mixes ranged from 32.39 to 40.16 percent. Scores are averaged on ten trials.

Table 7. Body and texture scores on ice milk using 12 percent sucrose, 3 percent CSS DE 42 and varying the CSS DE 24 from 0 to 8 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
I A	12	3	0	28.0
I B	12	3	1	28.2
I C	12	3	2	28.7
I D	12	3	3	28.7
I E	12	3	4	28.9
I F	12	3	5	28.7
I G	12	3	6	29.3
I H	12	3	7	29.1
I I	12	3	8	29.2

As indicated in above table, body and texture of the ice milk improved as the amount of DE 24 increased up to 6 percent with little difference where 7 or 8 percent was used.

Table 8. Flavor scores on ice milk using 12 percent sucrose, 3 percent CSS DE 42 and varying the CSS DE 24 from 0 to 8 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
I A	12	3	0	38.4
I B	12	3	1	39.0
I C	12	3	2	39.0
I D	12	3	3	39.1
I E	12	3	4	39.1
I F	12	3	5	39.3
I G	12	3	6	39.3
I H	12	3	7	39.3
I I	12	3	8	38.9

Table 8 indicates very little difference in flavor scores as the DE 24 was increased up to 8 percent. At this point a slight syrup flavor was observed on all trials.

Comparisons of formulae in series I of ice milk by consumer preference tests as shown in the following tables help to confirm the previous results.

Table 9. Consumer ratings on 5 samples of ice milk from series I

Placing	Formulae				
	A (0% DE 24)	C (2% DE 24)	E (4% DE 24)	G (6% DE 24)	I (8% DE 24)
1	0	0	5	1	3
2	0	2	0	3	4
3	0	4	3	1	1
4	1	3	1	3	1
5	8	0	0	1	0

The results as shown by the above table indicate a preference for the two samples containing 4 and 8 percent DE 24.

Table 10. Consumer ratings on 4 samples of ice milk from series I

Placing	Formulae			
	B (1% DE 24)	D (3% DE 24)	F (5% DE 24)	H (7% DE 24)
1	1	4	1	3
2	3	0	6	0
3	1	4	1	3
4	4	1	1	3

The results as shown by the above table indicate a preference for samples containing 3 percent DE 24 and 5 percent DE 24.

Table 11. Consumer ratings on the best samples from tables 9 and 10

Placing	Formulae			
	D (3% DE 24)	E (4% DE 24)	F (5% DE 24)	I (8% DE 24)
1	1	2	2	3
2	1	2	4	2
3	2	3	2	1
4	4	1	0	2

Table 11 reveals that an increase of DE 24 up to 5 percent gives the most desirable products as rated by the consumer jury. An increase up to 8 percent was not objectionable.

Series II. In series II a comparison was made using the formulae judged first and second best in series I and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24. Scores are averaged on only two trials as the amount of DE 31 was limited.

Table 12. Body and texture scores on ice milk using 12 percent sucrose in combination with varying amounts of CSS DE 42 and DE 24, and duplicate formulae using DE 31 to replace both DE 42 and DE 24

Formula	% Sucrose	% DE 42	% DE 24	% DE 31	Average score
II A	12	3	6		29.5
II B	12	3	7		29.5
II C	12			9(solids)	29.0
II D	12			10(solids)	29.5

The above table shows there is practically no difference where DE 31 replaced the other two corn syrup solids in ice milk.

Table 13. Flavor scores on ice milk using 12 percent sucrose in combination with varying amounts of CSS DE 42 and DE 24, and duplicate formulae using DE 31 to replace both DE 42 and DE 24.

Formula	% Sucrose	% DE 42	% DE 24	% DE 31	Average score
II A	12	3	6		40.0
II B	12	3	7		40.0
II C	12			9(solids)	40.0
II D	12			10(solids)	40.0

Table 13 shows the average flavor scores in this comparison to be identical.

Series III. In series III the best formula in series I was used as a representative product of corn syrup solids. Two other formulae containing low lactose N.F.D.M.S. were compared with this mix. An accepted formula using 5 percent low lactose N.F.D.M.S. to build the total solids, and a modified formula using a smaller amount of low lactose N.F.D.M.S. with an increase in corn syrup solids were included in this phase of the experiment. The latter formula was used in an

effort to prevent syrup flavor, condensed milk or cooked flavor, and sandiness in body and texture. The total solids of all three mixes were equal at 38.2 percent.

Table 14. Body and texture scores on ice milk in series III using corn syrup solids, low lactose N.F.D.M.S., and regular N.F.D.M.S. to help build the total solids

Formula	% DE 42	% DE 24	% Low lactose N.F.D.M.S.	% Serum solids	Average score
III A	3	6		13	29.3
III B	4		5	13	28.0
III C	3	6	3	10	29.5

The results of the above table favor the combination formula (III C). The low lactose N.F.D.M.S. formula (III B) had a lower body and texture average score than the other two.

Table 15. Flavor scores on ice milk in series III using corn syrup solids, low lactose N.F.D.M.S., and regular N.F.D.M.S. to help build the total solids

Formula	% DE 42	% DE 24	% Low lactose N.F.D.M.S.	% Serum solids	Average score
III A	3	6		13	39.5
III B	4		5	13	38.0
III C	3	6	3	10	40.0

The results of the above table favor the combination formula (III C). The low lactose N.F.D.M.S. formula (III B) had a lower average flavor score due to the criticism of condensed milk products flavor.

The addition of corn syrup solids of varying amounts showed no significant differences in melt down characteristics in the ice milk phase of the experiment.

To help determine the consumer acceptance of ice milk in comparison with ice cream, six varieties were made of each and offered for sale at the college dairy store. The sales were made in cones with the price of ice milk being lower than the price of the ice cream.

Table 16. Consumer acceptance of ice milk compared to ice cream by sales volume for a period of three weeks

Flavor	Ice Cream	Ice Milk
	% of total sales	% of total sales
Vanilla	74	26
Chocolate	60	40
Strawberry	79	21
Butter Brickle	64	36
Strawberry Ripple	54	46
Cherry Vanilla	74	26
	67	33

From the results indicated in above table, ice cream leads in two-thirds of the sales on the campus; however, ice milk enjoys more popularity than was expected.

Sherbet analysis and data

Series I. Series I included nine formulae with the following sweeteners: 12 percent sucrose sugar, 9 percent DE 42, and the DE 24 varied from 0 to 8 percent. The total solids of these mixes ranged from 27.73 to 35.53 percent. Scores were averaged on 5 trials.

Table 17. Body and texture scores on sherbet using 12 percent sucrose, 9 percent CSS DE 42, and varying the CSS DE 24 from 0 to 8 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
I A	12	9	0	27.5
I B	12	9	1	27.5
I C	12	9	2	28.4
I D	12	9	3	28.5
I E	12	9	4	29.0
I F	12	9	5	29.0
I G	12	9	6	29.0
I H	12	9	7	29.4
I I	12	9	8	29.2

Table 17 shows a definite improvement in body and texture with the addition of DE 24 up to 7 percent and very little decline in average score when DE 24 was added at the rate of 8 percent.

Table 18. Flavor scores on sherbet using 12 percent sucrose, 9 percent CSS DE 42 and varying the CSS DE 24 from 0 to 8 percent

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	Average score
I A	12	9	0	39.9
I B	12	9	1	39.9
I C	12	9	2	39.9
I D	12	9	3	39.9
I E	12	9	4	39.2
I F	12	9	5	39.2
I G	12	9	6	40.0
I H	12	9	7	39.9
I I	12	9	8	39.9

The above table indicates there is no difference in average score with the addition of DE 24 up to as high as 8 percent. Samples containing 4 and 5 percent had lower average scores because of the criticisms on the flavor of the fruits added.

Series II. In series II a comparison was made using the formulae judged first and second best in series I, and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24. Scores were averaged on only one trial as the amount of DE 31 was limited.

Table 19. Body and texture scores on sherbet using 12 percent sucrose in combination with varying amounts of CSS DE 42 and DE 24, and duplicate formulae using DE 31 to replace both DE 42 and DE 24

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	% CSS DE 31	Average score
II A	12	9	7		29.0
II B	12	9	8		29.5
II C	12			16(solids)	29.0
II D	12			17(solids)	29.0

Table 19 indicates there is practically no difference when DE 42 and DE 24 are replaced by DE 31 in sherbets.

Table 20. Flavor score on sherbet using 12 percent sucrose in combination with varying amounts of CSS DE 42 and DE 24, and duplicate formulae using DE 31 to replace both DE 42 and DE 24

Formula	% Sucrose	% CSS DE 42	% CSS DE 24	% CSS DE 31	Average score
II A	12	9	7		38.5
II B	12	9	8		39.5
II C	12			16(solids)	38.5
II D	12			17(solids)	38.5

The above table shows there is very little difference in flavor scores when DE 42 and DE 24 are replaced with DE 31. The criticisms made on formulae II A, II C, and II D were against the fruit and had no reflection on the sweeteners used.

Comparison of formulae used in series I of sherbets by consumer preference tests as shown in the following table helps to confirm the previous results.

Table 21. Consumer ratings on formulae used in series I of sherbet using 12 percent sucrose, 9 percent CSS DE 42 and varying the CSS DE 24 from 0 to 8 percent

Placing	Formulae								
	A (DE 24) 0%	B (DE 24) 1%	C (DE 24) 2%	D (DE 24) 3%	E (DE 24) 4%	F (DE 24) 5%	G (DE 24) 6%	H (DE 24) 7%	I (DE 24) 8%
1st	1	2	1	2	0	2	3	1	2
2nd	0	1	2	2	1	0	2	5	1
3rd	0	1	0	3	1	2	2	3	3
4th	3	0	1	0	1	0	4	2	2
5th	2	2	3	1	3	1	0	0	2
6th	0	0	0	0	7	4	0	1	2
7th	0	2	4	0	1	3	1	1	1
8th	1	5	0	5	0	2	1	1	1
9th	7	1	3	1	0	0	1	0	0

Results of the above table indicate that the addition of DE 24 up to 6 percent found the most favor with the consumer, with very little difference noted for amounts up to 7 and 8 percent.

CONCLUSIONS

On the basis of the preceding data and the completion of the study, the following conclusions are presented:

1. Approximately 25 percent of the sucrose in ice cream can be replaced with corn syrup solids (DE 24 and 42 or 31) without appreciably impairing the flavor.

2. In ice milk the corn syrup solids (DE 24 and 42 or 31) and sucrose combination may reach as high as 22 percent of the total weight without impairing the flavor; corn syrup solids represent about 45 percent of the combination.

3. It is indicated that sherbet flavor is not impaired by a combination as high as 17 percent corn syrup solids (DE 24 and 42 or 31) and 12 percent sucrose. Further work with DE 31 is necessary to reach a more definite conclusion.

4. Corn syrup solids (DE 24 and 42 or 31) in combination with sucrose was beneficial in building body and texture in frozen desserts if the optimum amounts are used. Too little corn syrup solids resulted in a coarser and weaker product, while too much tended toward making the product sticky. The use of approximately 2 percent DE 24 is recommended with 3 percent DE 42 in ice cream; 6 percent DE 24 with 3 percent DE 42 in ice milk; and 7 percent DE 24 with 9 percent DE 42 in sherbets. Twelve percent sucrose was used in the above combinations.

5. The use of corn syrup solids in building body and texture in frozen desserts is the most economical way from a comparative cost basis.

6. Where moderate amounts of stabilizer are used, the corn syrup solids (DE 24 and 42 or 31) exerted no significant effect on the melting quality.

7. Results of this study indicate that larger amounts of corn syrup solids may be used to increase the total solids and improve the body and texture of frozen desserts if corn syrup solids of a lower dextrose equivalent are used.

8. Corn syrup solids with a DE of 31 compared favorably with a combination of DE 42 and DE 24 in the manufacture of frozen desserts. However, the ease of handling DE 24 and 42 which are in powder form in comparison to DE 31 which ~~is~~ was a syrup places the balance of favor with the powders.

SUMMARY

1. Because of the increasing importance of corn syrup solids to the ice cream industry, studies were made as to the effectiveness of these products in building body and texture of frozen desserts.

2. Studies of other research workers indicate that corn sweeteners have a definite place in the manufacture of frozen desserts.

3. The corn syrup solids used in this experiment varied in their dextrose equivalents. Corn syrup solids DE 24 and DE 42, and corn syrup DE 31 were included in the study.

4. Samples of ice cream, ice milk, and sherbets were manufactured using corn syrup solids in various combinations with sucrose sugar.

5. The optimum amounts to use for fine flavor, smooth body and texture, and desirable melt down were observed.

6. Samples were scored in compliance with the rules of the American Dairy Science Association.

7. The scope of the experiment included judgment by experts of the industry and people considered as average consumers.

8. The results of this study indicate the most desirable combinations of sucrose and corn syrup solids are:

Ice cream
13 percent sucrose, 2 percent DE 42
and 1 percent DE 24

Ice milk
12 percent sucrose, 3 percent DE 42
and 6 percent DE 24

Sherbet
12 percent sucrose, 9 percent DE 42
and 7 percent DE 24

10. The combination of DE 42 and DE 24 can be replaced with DE 31 without impairing the quality of the product.

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APPENDIX

Formulae for ice cream using 15 percent sucrose and 0 to 3 percent CSS DE 24 as sweeteners:

Series I, Formula A. 15 percent sucrose and 0 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.2		14.2
23.2	Condensed skim milk		7.5		7.5
25.0	Skim milk		2.3		2.3
15.0	Sucrose sugar			15.0	15.0
0.0	DE 24				0.0
0.3	Dariloid				0.3
0.1	E4CS				0.1
100.0		12.0	12.0	15.0	39.4

Series I, Formula B. 15 percent sucrose and 1 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.20		14.20
23.7	Condensed skim milk		7.70		7.70
23.5	Skim milk		2.10		2.10
15.0	Sucrose sugar			15.0	15.00
1.0	DE 24				0.97
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.00	15.0	40.37

Series I, Formula C. 15 percent sucrose and 2 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.20		14.20
24.0	Condensed skim milk		7.80		7.80
22.2	Skim milk		2.00		2.00
15.0	Sucrose sugar			15.00	15.00
2.0	DE 24				1.94
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.00	15.00	41.34

Series I, Formula D. 15 percent sucrose and 3 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.20		14.20
24.4	Condensed skim milk		7.93		7.93
20.8	Skim milk		1.87		1.87
15.0	Sucrose sugar			15.00	15.00
3.0	DE 24				2.91
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.00	15.00	42.31

Formulae for ice cream using 13 percent sucrose, 2 percent CSS DE 42 and 0 to 3 percent CSS DE 24 as sweeteners:

Series II, Formula A. 13 percent sucrose, 2 percent DE 42 and 0 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.2		14.20
23.2	Condensed skim milk		7.5		7.50
25.0	Skim milk		2.3		2.30
13.0	Sucrose sugar			13.0	13.00
2.0	DE 42				1.94
0.0	DE 24				0.00
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.0	13.0	39.34

Series II, Formula B. 13 percent sucrose, 2 percent DE 42 and 1 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.2		14.20
23.7	Condensed skim milk		7.7		7.70
23.5	Skim milk		2.1		2.10
13.0	Sucrose sugar			13.0	13.00
2.0	DE 42				1.94
1.0	DE 24				0.97
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.0	13.0	40.31

Series II, Formula C. 13 percent sucrose, 2 percent DE 42 and 2 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.2		14.20
24.0	Condensed skim milk		7.8		7.80
22.2	Skim milk		2.0		2.00
13.0	Sucrose sugar			13.00	13.00
2.0	DE 42				1.94
2.0	DE 24				1.94
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.0	13.00	41.28

Series II, Formula D. 13 percent sucrose, 2 percent DE 42 and 3 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.20		14.20
24.4	Condensed skim milk		7.93		7.93
20.8	Skim milk		1.87		1.87
13.0	Sucrose sugar			13.00	13.00
2.0	DE 42				1.94
3.0	DE 24				2.91
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.0	12.00	13.00	42.25

Formulae for ice cream using 11 percent sucrose, 4 percent CSS DE 42 and 0 to 3 percent CSS DE 24 as sweeteners:

Series III, Formula A. 11 percent sucrose, 4 percent DE 42 and 0 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.00	2.20		14.20
23.2	Condensed skim milk		7.50		7.50
25.0	Skim milk		2.30		2.30
11.0	Sucrose sugar			11.00	11.00
4.0	DE 42				3.88
0.0	DE 24				0.00
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.00	12.00	11.00	39.28

Series III, Formula B. 11 percent sucrose, 4 percent DE 42 and 1 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.00	2.20		14.20
23.7	Condensed skim milk		7.70		7.70
23.5	Skim milk		2.10		2.10
11.0	Sucrose sugar			11.00	11.00
4.0	DE 42				3.88
1.0	DE 24				0.97
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.00	12.00	11.00	40.25

Series III, Formula C. 11 percent sucrose, 4 percent DE 42 and 2 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.00	2.20		14.20
24.0	Condensed skim milk		7.80		7.80
22.2	Skim milk		2.00		2.00
11.0	Sucrose sugar			11.00	11.00
4.0	DE 42				3.88
2.0	DE 24				1.94
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.00	12.00	11.00	41.22

Series III, Formula D. 11 percent sucrose, 4 percent DE 42 and 3 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.00	2.20		14.20
24.4	Condensed skim milk		7.93		7.93
20.8	Skim milk		1.87		1.87
11.0	Sucrose sugar			11.00	11.00
4.0	DE 42				3.88
3.0	DE 24				2.91
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.00	12.00	11.00	42.19

Formulae for ice cream using the best mix in series II and III with CSS DE 42, DE 24, and sucrose as sweeteners compared to the same formulae using CSS DE 31 and sucrose as sweeteners:

Series IV, Formula A is duplication of mix scoring highest in series II. Formula B of series II represents this mix.

Series IV, Formula B is duplication of mix scoring highest in series III. Formula A of series III represents this mix.

Series IV, Formula C. Same as Formula B of series II except DE 24 and DE 42 are replaced by DE 31

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.20		14.20
23.9	Condensed skim milk		7.77		7.77
22.6	Skim milk		2.03		2.03
13.0	Sucrose sugar			13.00	13.00
3.7	DE 31				2.88
0.3	Dariloid				0.30
0.1	E4CS				0.10
100.0		12.00	12.00	13.00	40.28

Series IV, Formula D. Same as Formula A of series III except DE 42 is replaced by DE 31

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
36.4	Cream	12.0	2.2		14.2
23.7	Condensed skim milk		7.7		7.7
23.5	Skim milk		2.1		2.1
11.0	Sucrose sugar			11.0	11.0
5.0	DE 31			[illegible]	3.9
0.3	Dariloid				0.3
0.1	E4CS				0.1
100.0		12.0	12.0	11.0	39.3

DE 24 and DE 42 computed on dry matter basis of 97.0 percent solids and DE 31 computed on dry matter basis of 77.75 percent solids.

Body and texture scores on ice cream for series I. Sweeteners used included 15 percent sucrose with no CSS DE 42 and 0 percent DE 24 in Formula I A, 1 percent in Formula I B, 2 percent in Formula I C, and 3 percent in Formula I D.

Trial	I A - Score & criticism	I B - Score & criticism	I C - Score & criticism	I D - Score & criticism
1	28.5 coarse	28.5 sl. coarse	29.5	29.0 sl. sticky
2	28.0 coarse	29.0 sl. sticky	29.0 sl. sticky	29.5
3	29.0 sl. coarse	29.0 sl. coarse	29.5	29.0 sl. sticky
4	28.0 coarse	29.0 sl. coarse	29.5	29.0 sl. sticky
5	29.0 sl. coarse	29.0 sl. coarse	29.5	29.0 sl. sticky

Flavor scores on ice cream for series I. Sweeteners used included 15 percent sucrose with no CSS DE 42 and 0 percent DE 24 in Formula I A, 1 percent in I B, 2 percent in I C, and 3 percent in I D.

Trial	I A - Score & criticism	I B - Score & criticism	I C - Score & criticism	I D - Score & criticism
1	40.0	40.0	40.0	39.0 sl. syrup
2	40.0	40.0	40.0	39.0 sl. syrup
3	40.0	40.0	40.0	39.0 sl. syrup
4	40.0	40.0	39.0 sl. syrup	39.0 sl. syrup
5	38.0 metallic	39.5 sl. coarse	40.0	39.0 sl. syrup

Body and texture scores on ice cream for series II. Sweeteners used included 13 percent sucrose, 2 percent CSS DE 42 and 0 percent DE 24 in Formula II A, 1 percent in Formula II B, 2 percent in Formula II C, and 3 percent in Formula II D.

Trial	II A - Score & criticism	II B - Score & criticism	II C - Score & criticism	II D - Score & criticism
1	28.5 sl. coarse	29.5	29.5 sl. sticky	29.0 sl. sticky
2	28.5 sl. coarse	29.0 sl. weak	29.0 sl. sticky	29.5
3	29.5	29.5	29.5	29.5
4	29.0 sl. coarse	29.5	29.0 sl. sticky	29.0 sl. sticky
5	29.0 sl. weak	29.5	29.0 sl. sticky	29.0 sl. sticky

Flavor scores on ice cream for series II. Sweeteners used included 13 percent sucrose, 2 percent CSS DE 42 and 0 percent DE 24 in Formula II A, 1 percent in Formula II B, 2 percent in Formula II C and 3 percent in Formula II D.

Trial	II A - Score & criticism	II B - Score & criticism	II C - Score & criticism	II D - Score & criticism
1	39.5 sl. coarse	40.0	39.0 sl. syrup	39.0 sl. syrup
2	39.5	39.5	39.0 sl. syrup	39.0 sl. syrup
3	40.0	40.0	39.5	39.0 sl. syrup
4	40.0	39.5	39.0 sl. syrup	39.0 sl. syrup
5	39.5 sl. coarse	40.0	39.0 sl. syrup	39.0 sl. syrup

Body and texture scores on ice cream for series III. Sweeteners used included 11 percent sucrose, 4 percent CSS DE 42 and 0 percent DE 24 in Formula III A, 1 percent in Formula III B, 2 percent in Formula III C, and 3 percent in Formula III D.

Trial	III A-Score & criticism	III B-Score & criticism	III C-Score & criticism	III D-Score & criticism
1	29.5	28.5 sl. sticky	29.0 sl. sticky	29.0 sl.sticky
2	28.5 sl. coarse	28.5 sl. sticky	29.5	29.0 sl. sticky
3	29.5	29.0 sl. sticky	29.0 sl. sticky	29.0 sl. sticky
4	29.0 sl. weak	29.5	29.0 sl. sticky	29.0 sl. sticky
5	29.5	29.0 sl. sticky	29.0 sl. sticky	29.5 sl. sticky

Flavor scores in ice cream for series III. Sweeteners used included 11 percent sucrose, 4 percent CSS DE 42 and 0 percent DE 24 in Formula III A, 1 percent in Formula III B, 2 percent in Formula III C and 3 percent in Formula III D.

Trial	III A-Score & criticism	III B-Score & criticism	III C-Score & criticism	III D-Score & criticism
1	40.0	40.0	40.0	39.0 sl. syrup
2	40.0	40.0	40.0	39.0 sl. syrup
3	40.0	39.5	40.0	39.0 sl. syrup
4	39.5	40.0	39.0 sl. syrup	39.0 sl. syrup
5	40.0	39.5	39.0 sl. syrup	39.0 sl. syrup

Body and texture scores on ice cream series IV. A comparison was made using the formulae judged best in series II and series III and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24.

Trial	IV A -Score & criticism	IV B - Score & criticism	IV C - Score & criticism	IV D - Score & criticism
1	30.0	29.5	28.5 sl. coarse	29.0 sl. coarse
2	29.5	29.5	28.5 sl. coarse	29.0 sl. coarse

Flavor scores on ice cream series IV. A comparison was made using the formulae judged best in series II and series III and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24.

Trial	IV A -Score & criticism	IV B -Score & criticism	IV C -Score & criticism	IV D -Score & criticism
1	40.0	40.0	40.0	40.0
2	40.0	40.0	40.0	40.0

There were only two ice cream formulae criticized on melt down characteristics. Series I Formula D was criticized on 1 trial for being slightly curdy and in Series II Formula A was criticized on 2 trials for being slightly curdy.

Formulae for ice milk using 12 percent sucrose, 3 percent CSS DE 42 and 0 to 8 percent CSS DE 24 as sweeteners:

Series I, Formula A. 12 percent sucrose, 3 percent DE 42 and 0 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
24.5	Condensed skim milk		7.96		7.96
47.9	Skim milk		4.31		4.31
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
0.0	DE 24				0.00
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	12.99	12.00	32.39

Series I, Formula B. 12 percent sucrose, 3 percent DE 42 and 1 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	.72		4.71
24.9	Condensed skim milk		8.09		8.09
46.5	Skim milk		4.19		4.19
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
1.0	DE 24				0.97
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	13.00	12.00	33.37

Series I, Formula C. 12 percent sucrose, 3 percent DE 42 and 2 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
25.3	Condensed skim milk		8.22		8.22
45.1	Skim milk		4.06		4.06
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
2.0	DE 24				1.94
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	13.00	12.00	34.34

Series I, Formula D. 12 percent sucrose, 3 percent DE 42 and 3 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
25.7	Condensed skim milk		8.35		8.35
43.7	Skim milk		3.93		3.93
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
3.0	DE 24				2.91
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	13.00	12.00	35.31

Series I, Formula E. 12 percent sucrose, 3 percent DE 42 and 4 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
26.1	Condensed skim milk		8.48		8.48
42.3	Skim milk		3.80		3.80
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
4.0	DE 24				3.88
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	13.00	12.00	36.28

Series I, Formula F. 12 percent sucrose, 3 percent DE 42 and 5 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
26.4	Condensed skim milk		8.58		8.58
41.0	Skim milk		3.69		3.69
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
5.0	DE 24				4.85
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	12.99	12.00	37.24

Series I, Formula G. 12 percent sucrose, 3 percent DE 42 and 6 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
26.8	Condensed skim milk		8.71		8.71
39.6	Skim milk		3.56		3.56
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
6.0	DE 24				5.82
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	12.99	12.00	38.21

Series I, Formula H. 12 percent sucrose, 3 percent DE 42 and 7 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
27.2	Condensed skim milk		8.84		8.84
38.2	Skim milk		3.44		3.44
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
7.0	DE 24				6.79
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	13.00	12.00	39.19

Series I, Formula I. 12 percent sucrose, 3 percent DE 42 and 8 percent DE 24

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
27.6	Condensed skim milk		8.97		8.97
36.8	Skim milk		3.31		3.31
12.0	Sucrose sugar			12.00	12.00
3.0	DE 42				2.91
8.0	DE 24				7.76
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	13.00	12.00	40.16

Formulae for ice milk using the mixes judged first and second best in series I with CSS DE 42, DE 24, and sucrose as sweeteners compared to the same formulae using CSS DE 31 and sucrose as sweeteners:

Series II, Formula A is duplication of mix scoring highest in series I. Formula G of series I represents this mix.

Series II, Formula B is duplication of mix scoring second highest in series I. Formula H of series I represents this mix.

Series II, Formula C. Same as Formula G of series I except DE 24 and DE 42 are replaced by DE 31

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
27.6	Condensed skim milk		8.97		8.97
36.7	Skim milk		3.30		3.30
12.0	Sucrose sugar			12.00	12.00
11.2	DE 31				8.70
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	12.99	12.00	38.18

Series II, Formula D. Same as Formula H of series I except DE 24 and DE 42 are replaced by DE 31

Weight in lbs.	Ingredient	Butterfat	Solids not fat	Sugar	Total solids
12.1	Cream	3.99	0.72		4.71
28.1	Condensed skim milk		9.13		9.13
34.8	Skim milk		3.14		3.14
12.0	Sucrose sugar			12.00	12.00
12.5	DE 31				9.70
0.4	Dariloid				0.40
0.1	E4CS				0.10
100.0		3.99	12.99	12.00	39.18

Body and texture scores on ice milk series I. Sweeteners used included 12 percent sucrose, 3 percent CSS DE 42 and 0 percent in Formula I A up to 8 percent in Formula I I, with a 1 percent increase in each successive formula from Formula I A to include Formula I I, of DE 24.

Trial	I A Score & criticism	I B Score & criticism	I C Score & criticism	I D Score & criticism	I E Score & criticism	I F Score & criticism	I G Score & criticism	I H Score & criticism	I I Score & criticism
1	27.0 coarse	28.0 coarse	29.0 sl. coarse	29.0 sl. coarse	29.5	28.0 coarse	29.5	29.5	29.5
2	27.0 coarse	27.0 coarse	27.5 coarse	27.0 coarse	28.0 sl.coarse	28.0 coarse	29.0 sl.coarse	29.0 sl.coarse	29.5
3	29.0 sl.coarse	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.0 sl.coarse
4	29.5	29.0 sl.coarse	28.0 coarse	29.0 sl.coarse	29.0 sl.coarse	29.0 sl.coarse	28.5 sl.coarse	29.0 sl.coarse	29.5
5	28.0 coarse	28.0 coarse	29.0 sl.coarse	28.5 sl.coarse	28.5 sl.coarse	28.5 sl.coarse	29.5	29.5	28.5 sl.coarse
6	29.0 sl.coarse	29.0 sl.coarse	29.5	30.0	29.0 sl.coarse	29.5	29.5	29.5	28.5 sl.coarse
7	26.5 coarse	26.5 coarse	28.0 coarse	27.5 coarse	29.0 sl.coarse	27.5 coarse	27.5 coarse	27.5 coarse	28.5 sl.coarse
8	29.0 sl.coarse	29.0 sl.coarse	28.0 coarse	29.0 sl.coarse	29.5	29.5	29.5	29.5	29.5
9	28.0 coarse	28.0 coarse	28.5 sl.coarse	29.0 sl.coarse	28.5 sl.coarse	29.0 sl.coarse	29.5	29.5	29.5
10	28.0 coarse	28.5 sl.coarse	29.0 sl.coarse	29.0 sl.coarse	28.5 sl.coarse	29.5	29.0 sl.coarse	29.0 sl.coarse	29.5

Flavor scores on ice milk series I. Sweeteners used included 12 percent sucrose, 3 percent CSS DE 42 and 0 to 8 percent DE 24.

Trial	I A Score & criticism	I B Score & criticism	I C Score & criticism	I D Score & criticism	I E Score & criticism	I F Score & criticism	I G Score & criticism	I H Score & criticism	I I Score & criticism
1	39.0 cooked	39.0 *l.s.	39.0 cooked	40.0	40.0	40.0	39.0 cooked	39.0 cooked	39.0 sl. syrup
2	39.0 sl.stale	39.5	39.0 sl.stale	39.5	39.5	39.5	40.0	40.0	39.0 sl. syrup
3	36.0 metallic	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 sl. syrup
4	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 sl. syrup
5	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 sl.syrup	39.0 cooked	39.0 sl.syrup	39.0 sl. syrup
6	38.0 * l.s.	39.0 cooked	39.0 cooked	39.0 cooked	39.0 sl.syrup	39.0 cooked	39.0 cooked	39.0 cooked	39.0 sl. syrup
7	38.0 * l.s.	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	40.0	39.0 sl. syrup
8	39.0 * l.s.	39.0 sl.stale	39.0 cooked	39.0 cooked	39.0 cooked	40.0	39.0 cooked	39.0 cooked	39.0 sl. syrup
9	38.0 cooked	39.0 cooked	39.5	39.0 cooked	39.0 cooked	40.0	40.0	39.5	39.0 sl. syrup
10	38.5 * l.s.	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	39.0 cooked	40.0	39.0 sl.syrup	39.0 sl. syrup

* Lacks sweetness (l.s.)

Body and texture scores on ice milk for series II. A comparison was made using the formulae judged first and second best in series I and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24.

Trial	II A -Score & criticism	II B -Score & criticism	II C -Score & criticism	II D -Score & criticism
1	29.5	29.5	29.0 sl. coarse	29.5
2	29.5	29.5	29.0 sl. coarse	29.5

Flavor scores on ice milk for series II. A comparison was made using the formulae judged first and second best in series I and comparing these with the same formulae using DE 31 to replace both DE 42 and DE 24.

Trial	II A -Score & criticism	II B -Score & criticism	II C -Score & criticism	II D -Score & criticism
1	40.0	40.0	40.0	40.0
2	40.0	40.0	40.0	40.0

Body and texture scores on ice milk series III. Corn syrup solids, low lactose N.F.D.M.S. and regular N.F.D.M.S. were varied in helping build the total solids of the mix.

Trial	III A -Score & criticism	III B -Score & criticism	III C -Score & criticism
1	29.5	28.0 sl. coarse	29.5
2	29.0 sl. coarse	28.0 sl. coarse	29.5
3	29.5	28.0 sl. coarse	29.5

Flavor scores on ice milk series III. Corn syrup solids, low lactose N.F.D.M.S. and regular N.F.D.M.S. were varied in helping to build the total solids of the mix.

Trial	III A -Score & criticism	III B -Score & criticism	III C -Score & criticism
1	39.5	38.0 condensed milk or cooked	40.0
2	39.5 sl. coarse lacks fine flavor	38.0 condensed milk or cooked	40.0
3	39.5 sl. coarse lacks fine flavor	38.0 condensed milk or cooked	40.0

Melt down criticism on ice milk , series I: Formula I A was criticized on 2 trials as being slightly curdy and on 8 trials had no criticisms. Formula I B was criticized on 1 trial as being slightly curdy, 1 trial criticized for delayed melting, and 8 trials had no criticisms. Formulae I C, I D, I E, I F, I G, I H, I I were each criticized on 1 trial as being slightly curdy and on the other 9 trials had no criticisms.

Melt down scores on all formulae in series II and III were constant at 5.0. No criticisms were noted.

Formulae for sherbets using 12 percent sucrose, 9 percent CSS DE 42 and 0 to 8 percent CSS DE 24 as sweeteners:

Series I, Formula A. 12 percent sucrose, 9 percent DE 42 and 0 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.73
0.0	DE 24			0.00
8.3	Water			0.00
100.0		6.30	12.00	27.73

Series I, Formula B. 12 percent sucrose, 9 percent DE 42 and 1 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.73
1.0	DE 24			0.97
7.3	Water			0.00
100.0		6.30	12.00	28.70

Series I, Formula C. 12 percent sucrose, 9 percent DE 42 and 2 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.73
2.0	DE 24			1.94
6.3	Water			0.00
100.0		6.30	12.00	29.67

Series I, Formula D. 12 percent sucrose, 9 percent DE 42 and 3 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.77
3.0	DE 24			2.91
5.3	Water			0.00
100.0		6.30	12.00	30.68

Series I, Formula E. 12 percent sucrose, 9 percent DE 42 and 4 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.77
4.0	DE 24			3.88
4.3	Water			0.00
100.0		6.30	12.00	31.65

Series I, Formula F. 12 percent sucrose, 9 percent DE 42 and 5 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.77
5.0	DE 24			4.85
3.3	Water			0.00
100.0		6.30	12.00	32.62

Series I, Formula G. 12 percent sucrose, 9 percent DE 42 and 6 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.77
6.0	DE 24			5.82
2.3	Water			0.00
100.0		6.30	12.00	33.59

Series I, Formula H. 12 percent sucrose, 9 percent DE 42 and 7 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.77
7.0	DE 24			6.79
1.3	Water			0.00
100.0		6.30	12.00	34.56

Series I. Formula I. 12 percent sucrose, 9 percent DE 42 and 8 percent DE 24

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
70.0	Skim milk	6.30		6.30
0.4	Gelatin			0.40
0.3	Surebet			0.30
12.0	Sucrose sugar		12.00	12.00
9.0	DE 42			8.77
8.0	DE 24			7.76
0.3	Water			0.00
100.0		6.30	12.00	35.53

Formulae for sherbet using the mixes judged first and second best in series I with CSS DE 42, DE 24, and sucrose as sweeteners compared to the same formulae using CSS DE 31 and sucrose as sweeteners:

Series II, Formula A is duplication of mix scoring highest in series I. Formula H of series I represents this mix.

Series II, Formula B is duplication of mix scoring second highest in series I. Formula I of series I represents this mix.

Series II, Formula C. Same as Formula H of series I except DE 24 and DE 42 are replaced by DE 31

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
65.00	Skim milk	5.85		5.85
0.50	N.F.D.M.S.	0.48		0.48
0.40	Gelatin			0.40
0.30	Surebet			0.30
12.00	Sucrose sugar		12.00	12.00
20.00	DE 31			15.55
1.80	Water			0.00
100.00		6.33	12.00	34.58

Series II, Formula D. Same as Formula I of series I except DE 24 and DE 42 are replaced by DE 31

Weight in lbs.	Ingredient	Milk Serum solids	Sugar	Total solids
65.00	Skim milk	5.85		5.85
0.50	N.F.D.M.S.	0.48		0.48
0.40	Gelatin			0.40
0.30	Surebet			0.30
12.00	Sucrose sugar		12.00	12.00
21.20	DE 31			16.95
0.60	Water			0.00
100.00		6.33	12.00	35.98

DE 24 and DE 42 computed on dry matter basis of 97.0 percent solids and DE 31 computed on dry matter basis of 77.75 percent solids.

Body and texture scores on sherbet series I. Sweeteners used included 12 percent sucrose, 3 percent CSS DE 42 and 0 to 8 percent DE 24.

Trial	I A Score & criticism	I B Score & criticism	I C Score & criticism	I D Score & criticism	I E Score & criticism	I F Score & criticism	I G Score & criticism	I H Score & criticism	I I Score & criticism
1	28.0 coarse	28.0 coarse	29.0 sl.coarse	28.5 sl.coarse	28.5 sl.coarse	29.0 sl.coarse	29.5	29.5	29.0 sl.crumbly
2	28.0 coarse	28.0 coarse	29.5	28.5 sl.coarse	28.5 sl.coarse	29.0 sl.coarse	29.0 sl.coarse	29.5	29.5
3	28.0 coarse	28.0 coarse	28.5 sl.coarse	28.5 sl.coarse	28.5 sl.coarse	29.0 sl.coarse	29.0 sl.coarse	29.0 sl.coarse	29.0 sl.crumbly
4	27.0 coarse	27.0 coarse	28.0 coarse	28.5 sl.coarse	28.5 sl.coarse	29.5	29.0 sl.coarse	29.5	29.0 sl.coarse
5	28.0 coarse	28.0 coarse	27.0 coarse	28.0 coarse	29.0 sl.coarse	28.5 sl.coarse	28.5 sl.coarse	29.5	29.5

Flavor scores on sherbet series I. Sweeteners used included 12 percent sucrose, 3 percent CSS DE 42 and 0 to 8 percent DE 24.

Trial	I A Score & criticism	I B Score & criticism	I C Score & criticism	I D Score & criticism	I E Score & criticism	I F Score & criticism	I G Score & criticism	I H Score & criticism	I I Score & criticism
1	40.0	40.0	40.0	39.5	39.5	39.5	40.0	40.0	40.0
2	40.0	40.0	40.0	40.0	38.5 *l.f.o.f.	38.5 *l.f.o.f.	40.0	40.0	39.5
3	40.0	40.0	40.0	40.0	38.0 *l.f.o.f.	38.0 *l.f.o.f.	40.0	39.5	40.0
4	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
5	39.5	39.5	39.5	40.0	40.0	40.0	40.0	40.0	40.0

* l.f.o.f. - Lacks fresh orange flavor.